THE ADVANCED ENERGY® PE 5000 GENERATOR

User Manual

Serial Number:_____

ADVANCED ENERGY INDUSTRIES, INC

1600 Prospect Parkway
Fort Collins, Colorado 80525
(303) 221-4670
Telex #45-0938

PN: 5700209
March 1990

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AE Japan	81 (03) 222-1311 ***Fax:*** 81 (03) 222-1315
all others	contact your local distributor -- see the list on the next page

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Before returning any product for repair and/or adjustment, call AE Customer Service and discuss the problem with them. Be prepared to give them the serial number of the unit and the reason for the proposed return. This consultation call will allow Customer Service to determine if the unit must actually be returned for the problem to be corrected. Such technical consultation is always available at no charge.

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Upgrading Units

AE will upgrade older units for a fee (a percentage of the current list price, based on the age of the unit. Such an upgraded unit will carry a 6-month warranty (which will be added to any time remaining on the original warranty).

WARNING

SAFE OPERATING PROCEDURES AND PROPER USE OF THE EQUIPMENT ARE THE RESPONSIBILITY OF THE USER OF THIS SYSTEM.

Advanced Energy Industries, Inc., provides information on its products and associated hazards, but it assumes no responsibility for the after-sale operation of the equipment or the safety practices of the owner or user.

This equipment produces potentially lethal high-voltage, high-current, radio frequency (RF) energy. You should read this manual and understand its contents before you attempt to hook up or operate the equipment it describes. Follow all safety precautions. **Never defeat interlocks or grounds**.

DANGER! All personnel who work with or who are exposed to this equipment must take precautions to protect themselves against serious or possibly fatal bodily injury.

DO NOT BE CARELESS AROUND THIS EQUIPMENT.

CONGRATULATIONS ...

On your purchase of AE's PE series generator, designed for hard use in a vacuum environment. Advanced circuit design and calibrated instrumentation make these units the most accurate, most efficient, and most versatile in the world today.

Since 1981, AE's power supplies and controllers have been contributing to a broad range of advanced technological processes such as semiconductor fabrication, optical coating, printed circuit manufacturing, glass coating, and data storage media plating. In the United States, Europe, and Asia, Advanced Energy Industries, Inc., is known for its quality products and strong customer support.

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INTRODUCTION

GUIDE TO INTERPRETING THE MANUAL

Overview of the Manual

The main table of contents is an outline of the major topics covered in the manual. It shows each chapter and the major sections of each chapter. It contains only the major sections so that you can skim it and get a general idea of what is contained here, without having to look at a lot of headings. In the manual, the chapter titles and the major sections are printed at the top right-hand corner of each odd-numbered page.

When you turn to a chapter, you will find a detailed table of contents that lists each subheading in the chapter. This will show you which page contains the information you are looking for.

Part 1, Getting to Know Your PE Series Generator, contains two chapters: What It Is and How It Works. What It Is gives an overview of the PE and a description of the functional and physical specifications.

How It Works contains a functional block diagram, a description of the front panel controls and status indicators, and important information on connectors and signal descriptions.

Part II, Operating Your PE Series Generator, also contains two chapters: Preparing for Use and Choosing Modes. Preparing for Use provides information on unpacking, connecting, and starting up your PE. Choosing Modes tells you how to select remote control.

Part III, Servicing Your PE Series Generator, contains one chapter, Calibration and Troubleshooting. This chapter tells you how to adjust the PE and service minor problems.

Part IV, The AE Load-matching Module, describes the load-matching module and tells you how to install it.

Type Conventions

To help you quickly pick out what is being discussed, the manual presents certain words and phrases in type that is different from the rest of the text. Pin and line names appear in capitalized italics (*POWCOM*). Labels that are on the PE (switches, indicators, etc.) generally appear in boldface capital letters (**PLASMA**). Functions are printed in boldface lowercase letters (**on/off**).

PART I

GETTING TO KNOW YOUR PE SERIES GENERATOR

PART I

WHAT IT IS

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GENERAL DESCRIPTION

The PE series power supply is designed as a power source for plasma processes. The unit delivers power and holds power at the specified level during plasma variations.

You can control the output and monitor the unit either from the front panel or through an I/O connector provided on the rear panel. PE series units easily interface with most logic types and both relay and switch contact closures.

The PE series uses a resonant power conversion technique coordinated with a highly effective line filter. This produces extremely efficient operation typical of switching power supplies while maintaining the low electromagnetic interference (EMI) of linear power supplies.

Understanding Switch-mode Operation

There are two basic approaches to ac power generation. The first, most common, is linear operation. The second, more recent development, is switch-mode operation. The following discussion explains the significant differences between the two types of operation.

Both linear and switch-mode supplies use an input rectifier/filter; however, linear supplies require a large 60-Hz step up/step down transformer. This transformer means that linear supplies are larger and heavier than switching supplies of the same power rating.

Another significant difference between linear and switching power supplies of a given frequency is the control element. Linear supplies use transistors or tubes as variable resistors that gradually change their value in response to a control signal. This gradual change causes the supply to dissipate nearly as much (possibly more) heat as the load. If transistors are used, an additional problem called "secondary breakdown" is common. Secondary breakdown prevents full device use, so large numbers of devices must be combined to produce the required power.

In contrast, switch-mode supplies use transistors optimized for rapid "turn on" and "turn off" in series with the load. Because each switch is always either fully on or off, switch-mode supplies dissipate significantly less power than do linear supplies.

One drawback of using switching supplies with plasma processes is that a plasma requires a current or "energy" source for proper stabilization. Most switching supplies are voltage sources.

The PE series deals with this problem in a unique fashion. First, a reactive power filter with a pass characteristic at the fundamental frequency acts as an energy source. The filter supplies both the voltage and current that the plasma requires for stability, and in addition, isolates transients (arcs, for example) from the generator. Because of the smoothing effect of the filter, the switches can be pulse-width modulated, and power control is attained with the same devices used for power generation. Hence the description, pulse-width modulated resonant inverter.

Functional Specifications

Controlling Modes	Local (through the front panel), remote (through the User I/O port).
Control Signal Sources	Power output can be controlled by internal analog signals entered from the front panel, or by external analog signals provided from the user I/O port.
Power Output	Low frequency output controlled in the constant power mode.
Interlock Supervision	When connected to a safety switch, the interlock string disables the unit if a problem occurs.
Status Indicators	LED's on front panel show status of interlocks, output enable, plasma ignition, and setpoint level. Remote or local control is also shown.
Fault Conditions	Overtemperature and arc are the conditions that shut off the output power.
Load-matching Transformer	Optional load-matching transformer. The transformer's taps allow the PE to efficiently transfer power to a wide range of loads.

Physical Specifications

Input Voltage	208 V ac ± 10% 50/60 Hz three phase
Input Current	15 A nominal (full power) 0.92 power factor 20 A circuit breaker
Output Power	3000 W at 550 V nominal output
Output Frequency	100 kHz ± 100 Hz
Cooling	0° C to 45° C ambient; 9 inches of clearance to rear of unit required; 1 inch clearance on sides and top of unit
Humidity	0%-92%, noncondensing

HOW IT WORKS

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PART I

The PE converts ac line power into rectified dc voltage. The dc voltage provides an unregulated source for high-frequency inverters. The inverters convert the unregulated dc voltage to high-frequency ac voltage.
The following sections describe the functional units of the PE power supply. Figure 2-1 on page 2-4 shows the PE block diagram.

Circuit Breaker/EMC Filter

The circuit breaker located on the rear panel automatically protects the system wiring in the event of a failure. In some units a fuse is used instead of a circuit breaker. The internal EMC filter reduces the amount of high-frequency noise conducted to the power lines.

Main Contactor/Rectifier

The main contactor applies incoming ac voltage to the rectifier. The rectifier converts the ac input to unregulated dc voltage.

Filter/Soft Start

The input filter reduces EMI conducted at low frequencies. It also reduces the peak current through the rectifier and the dc filter capacitor, and provides a stable input impedance for the dc-to-ac regulator.

The soft start circuit prevents large surge currents when the input power is turned on. The circuit uses a 50 Ω resistor to charge the dc filter capacitor and then shorts this resistor when the dc filter cap is charged to the normal operating level.

Auxiliary Power Supply

The auxiliary power supply is a 50/60 Hz transformer with an isolated 40 V ac center-tapped winding. The secondary winding generates ± 24 V dc to power the control electronics.

Drive Board

The drive board provides isolation between the control logic and the inverter.

Inverter/Frequency Module/Output Transformer

The inverter chops the dc voltage into a square wave ac voltage that passes through a series resonant circuit to produce a sine wave. This sine wave passes through an isolation (output) transformer.

Output Sense

The output sense converts and isolates output voltage and current to logic levels.

Display/User I/O

The display provides status information and control from the front panel. The user I/O port interface provides status and control for the remote interface.

Logic

The logic provides fault protection, on/off control, and power regulation.

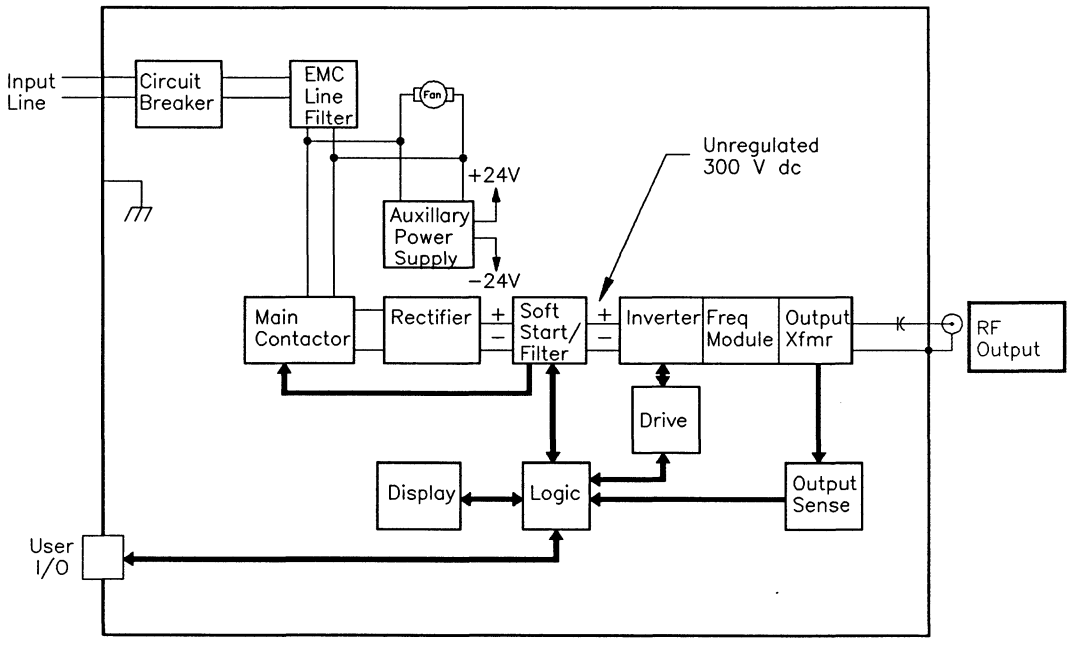


Figure 2-1. PE block diagram.

Front Panel Controls

The switches described below provide complete control of the PE power supply from the front panel. Figure 2-2 on page 2-6 shows the front panel.

POWER ON/OFF — Applies line power to internal circuitry.

OUTPUT ON/OFF — **OFF** resets the interlocks and overtemperature fault and removes the output power. **OFF** resets in both local and remote modes. However, in remote mode, power remains off only as long as the switch is held off. **ON** enables power to be transferred to the output connector. **ON** works only in local mode.

LEVEL — Controls output power in local mode. Rotating the locking skirt clockwise locks the knob in position without changing the setpoint value. The control has 10 turns and 0.1% resolution.

REMOTE/LOCAL — The two-position switch under the **LEVEL** knob selects remote or local control for the signal that programs power level. The two-position switch located under **OUTPUT ON/OFF** switch selects remote or local control for enabling the output.

DISPLAY — A momentary toggle switch that selects values to read on the **MONITOR** display. The middle or neutral position displays power in kilowatts. The upper and lower positions display voltage and current, respectively. Analog values of these signals are continuously available at the rear I/O connector.

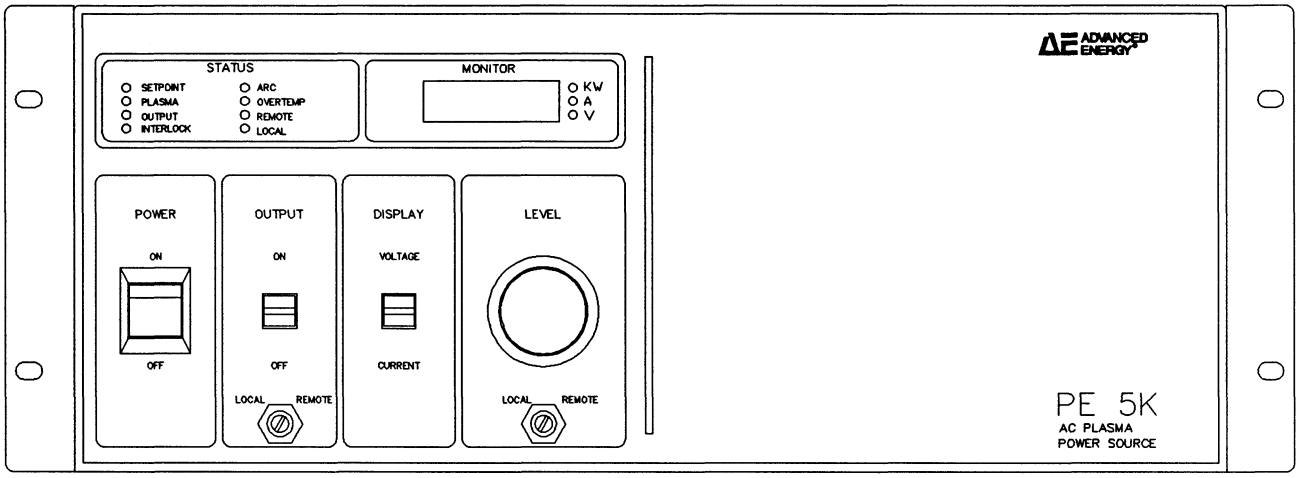


Figure 2-2. PE front panel.

Status Indicators

The PE power supply can be monitored by checking the following **STATUS** indicators on the front panel.

INTERLOCK

Lights when all interlocks are satisfied.
Flashes when the interlock chain is broken.
Unlit when the remote I/O connector is not in, the **OUTPUT OFF** momentary rocker position is actuated, or the remote *XOFF.D* command is active (high).

OUTPUT

Lights when the main contactor is closed, and the output is enabled and ready to deliver power.

PLASMA

Lights when over 1% of the full-scale output current has been reached (indicates plasma ignition).

SETPOINT

Lights when output power is within 0.2% of setpoint level.
Flashes when there is a plasma indicated, but output power is further than 0.2% from setpoint level.
Unlit when no plasma is present.

LOCAL

Lights to indicate unit is controlled through front panel.

REMOTE

Lights to indicate unit is being controlled through user I/O port.

OVERTEMP

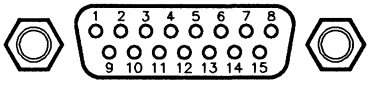
Flashes when the temperature of the unit exceeds the factory-set limit. This turns off the unit until the temperature sensor cools and the supply is reset by setting the **OUTPUT ON/OFF** switch momentarily to **OFF**.
Unlit when the operating temperature is normal.

ARC

Lights when an arc or an abnormally low process impedance occurs. The supply turns off within 1 ms after sensing this condition, withdraws the energy from the output power components, and in 3 ms reapplies power. The **ARC** indicator lights for 1 sec. after this event is sensed.

Analog/Digital I/O Connections

The user I/O interface uses the 15-pin, D subminiature, insulated connector shown below. The Pin-description Table gives a brief description of each pin, for a more detailed discussion see the page number referenced with each pin. Note: An ".A" appended to a pin name indicates an analog signal; a ".D" indicates a digital signal.



Pin-description Table

Pin	Name	Description	Refer to
1	*POWCOM*	digital and control common	Page 2-11
2	*24V*	can be either digital or analog, unregulated 24-V supply	Page 2-11
3	unassigned		
4	*XV.A*	output, 0-5 V	Page 2-11
5	*XSIG.A-*	input, 0-5 V, used with *pin 13*	Page 2-11
6	$\overline{\text{XSPT.D}}$	output, 0-15 V	Page 2-11
7	$\overline{\text{INTLK.D}}$	input, low -15 V dc to 3 V dc (a contact closure to *POWCOM* is sufficient low-logic level), high 11-30 V dc	Page 2-12
8	unassigned		
9	*SIGCOM*	analog common	Page 2-12

Pin	Name	Description	Refer to
10	unassigned		
11	XI.A	output, 0-5 V	Page 2-12
12	*XP.A*	output, 0-5 V	Page 2-12
13	*XSIG.A +*	input, 0-5 V, used with *pin 5*	Page 2-12
14	*XOFF.D*	input, low -15 V dc to 3 V dc (a contact closure to *POWCOM* is sufficient low-logic level), high 11-30 V dc, used with *pin 15*	Page 2-13
15	$\overline{XSON.D}$	input, low -15 V dc to 3 V dc (a contact closure to *POWCOM* is sufficient low-logic level), high 11-30 V dc, used with *pin 14*	Page 2-13

Signal Descriptions: User I/O Pins

An analog output is a 0-5 V dc signal referenced to *SIGCOM*. An analog input is a 0-5 V dc signal referenced to *XSIG.A-*. Both *XSIG.A-* and *XSIG.A+* must operate between 0 V and 10 V in reference to *SIGCOM*.

All input digital logic levels are as follows:

Low --
-15 V dc to 3 V dc
Note: A contact closure to *POWCOM* is a sufficient low-logic level.

High--
11 V dc to 30 V dc
Note: An open to the inputs is a sufficient high-logic level.

pin 1. POWCOM. This signal is a dedicated ground that returns to the internal system ground, then the chassis ground, and finally to the safety ground. All digital and control connections are referenced to *POWCOM*.

pin 2. 24V. This signal is a source of unregulated voltage between 22 V and 35 V with a 1/4 W, 100 Ω resistor in series. This may be used as a low current (maximum 50 mA) auxiliary power source (see the discussion of *pin 6,* $\overline{\text{XSPT.D}}$).

pin 3. unassigned

pin 4. XV.A This output signal provides a fully buffered 0-5 V dc signal representing full-scale output voltage at 600 V rms. The impedance of the *XV.A* output is 100 Ω.

pin 5. XSIG.A- This input signal and *XSIG.A+* (*pin 13*) provide a differential pair that can be used to linearly control the output power of the supply. This control point is active when the **REMOTE/LOCAL** switch on the front panel (units built after Feb. 1989) OR the DIP switch on the logic board (units built prior to Feb. 1989) is in the **REMOTE** position. See page 4-3 for more information on selecting remote control. A 0-5 V dc input provides linear control from 0 W to full power. The impedance of these inputs is 1 MΩ. The common mode range is 0-10 V.

pin 6. $\overline{\text{XSPT.D}}$ This output signal confirms that the power supply is delivering power at the programmed setpoint. The $\overline{\textit{XSPT.D}}$ output is a signal FET

switch referenced to *POWCOM*. The switch will "sink" 500 mA to drive most relays and will withstand 60 V open circuit. There is a 1-W, 57-V zener diode from the $\overline{\text{XSPT.D}}$ connection to *POWCOM*; this zener absorbs relay energy and protects the FET. An alternative is to place a resistor (5 kΩ minimum) between *pin 2* and $\overline{\text{XSPT.D}}$ to develop a logic output.

pin 7. $\overline{\text{INTLK.D}}$ This input signal is a secondary off command that disables the unit in the event of a high logic level in the interlock line. The interlock line is typically connected by the user to a safety switch, or a series of safety switches, referred to as an interlock string. These switches protect people, process, and equipment.

With the interlock string incomplete, the power supply's main contactor will not close. If the contactor is closed, and interlock is broken, the output power is disabled within 1 ms. On the PE front panel an **INTERLOCK** status indicator flashes when the interlock string is broken. To reset the **INTERLOCK** indicator, the interlock must be satisfied.

Circuit Specifications
The interlock circuitry has an internal 10 kΩ pull-up resistor to 15 V.

pin 8. unassigned

pin 9. SIGCOM. This signal is a dedicated ground that returns to the internal system ground, then the chassis ground, and finally to the safety ground. All analog connections are referenced to *SIGCOM*.

pin 10. unassigned

pin 11. XI.A This output signal provides a fully buffered 0-5 V dc signal representing full-scale output current of 6 A. The output impedance of the *XI.A* output is 100 Ω.

pin 12. XP.A This output signal provides a fully buffered 0-5 V dc signal representing full-scale output power. The output impedance of the *XP.A* output is 100 Ω.

pin 13. XSIG.A+ This input signal and *XSIG.A-* (*pin 5*) provide a differential pair that can be used to linearly control the output power of the supply. This control point is active when the **REMOTE/LOCAL** switch on the front panel (units built after Feb. 1989) OR the DIP switch on the logic board (units built prior to Feb. 1989) is in the **REMOTE** position. See page 4-3 for more information on selecting remote control. A 0-5 V dc input provides linear

control from 0 W to full power. The impedance of these inputs is 1 MΩ. The common mode range is 0-10 V.

pin 14. XOFF.D This input signal duplicates the **OFF** function of the front panel **OUTPUT ON/OFF** switch. A high logic level overrides all other commands and forces the output off, opening the main contactor, and resetting any interlock or overtemperature faults.

Circuit Specifications
The *XOFF.D* circuitry has an internal 10 kΩ pull-up resistor to 15 V. Circuit delay is less than 1 ms. While *XOFF.D* is active, only the **REMOTE** or **LOCAL** status indicator will light.

pin 15. $\overline{\text{XSON.D}}$ This input signal replaces the **ON** function of the front panel **OUTPUT ON/OFF** switch when the **REMOTE/LOCAL** switch on the front panel (units built after Feb. 1989) OR the DIP switch on the logic board (units built prior to Feb. 1989) is in the **REMOTE** position. See page 4-3 for more information on selecting remote control. A low logic level turns the supply on. *XOFF.D* must be low for $\overline{\textit{XSON.D}}$ to be active. For information on two-pin and three-pin wiring, see page 3-9.

Circuit Specifications
The $\overline{\textit{XSON.D}}$ circuitry has an internal 10 kΩ pull-up resistor to 15 V. While $\overline{\text{XSON.D}}$ is active, the main contactor remains closed, and the front panel **OUTPUT** status indicator lights.

PART I

PART II

OPERATING YOUR PE SERIES GENERATOR

PART II

PREPARING FOR USE

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Unpacking

Unpack and inspect your power supply carefully. Check for obvious physical damage to the exterior of the unit, and then remove the six phillips screws on the top cover of the supply.

Remove the top sheet metal to uncover the plexiglass safety shield. Without removing the safety shield, check for obvious signs of physical damage to the interior of the unit.

If no damage is apparent, reinstall the top sheet metal cover and proceed with the unit connections. If you do see signs of shipping damage, contact Advanced Energy Industries, Inc., and the carrier immediately. Save the shipping container for submitting necessary claims to the carrier.

Connecting Input Power

The PE 5000 requires 208-V, three-phase, 50/60 Hz input power with either a wye or delta connection. Three-phase rotation is not important.

To connect the input, place the input circuit breaker in the **OFF** position and attach the line cord to the 208-V, three-phase with ground.

Attach the ground stud (next to power cord) to the system ground with at least 14 gauge, stranded wire.

Once the connections are complete, lethal voltages are potentially present at the output connector. Be sure this connector is terminated and follow normal safety precautions when the system is operating.

Connecting Output Power

The main power output connector requires a standard HN plug. A typical combination is an Amphenol part #83-804 (Mil UG59B) and RG-8 cable or Amphenol part #8125 (Mil UG494) and RG 217 cable. There is no practical limit to the length of the cable. Use the following instructions to prepare the cable:

1. Strip the cable; be careful not to nick the braid, the dielectric, or the conductor.
2. Slip end "A", insulator "B", washer "C", and cone "D" onto the cable. Push cone "C" all the way onto the outer insulation. Cut the braided shield 0.25 in. from the cone.
3. Roll the braided shield back over cone "D". Cut the inner insulation and the center conductor to the dimensions shown.
4. Solder the tip to the center conductor.
5. Attach the outer cover.
6. Conduct a high-potential test for the insulation. Hi-pot the insulation to 3 kV dc between the center conductor and the outside shield.

YOU SHOULD KNOW...

When conducting a high-potential test, high voltages are present. Use extreme caution.

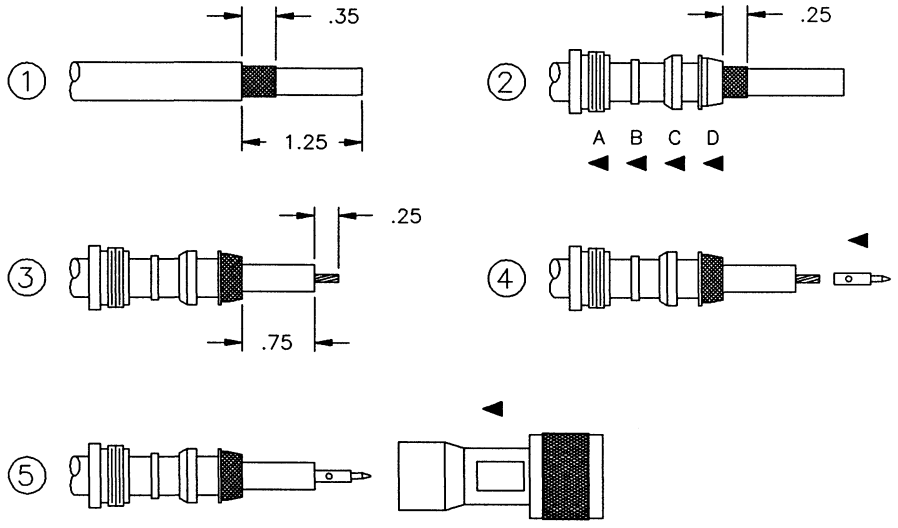

Figure 3-1. Preparing the RG-8 coaxial cable.

The unit is shipped with a dc-blocking capacitor in series with the center lead of the output connector. The capacitor is rated for full-output current and 400 V of dc bias or self bias of either polarity. The output connector shield is normally shipped grounded.

Connecting the User I/O Interface

The I/O connector attached to the rear of the supply is internally wired to allow preliminary operation from the front panel. Plug this connector into the 15-pin D connector at the rear of the unit. Figure 3-2 shows the rear panel.

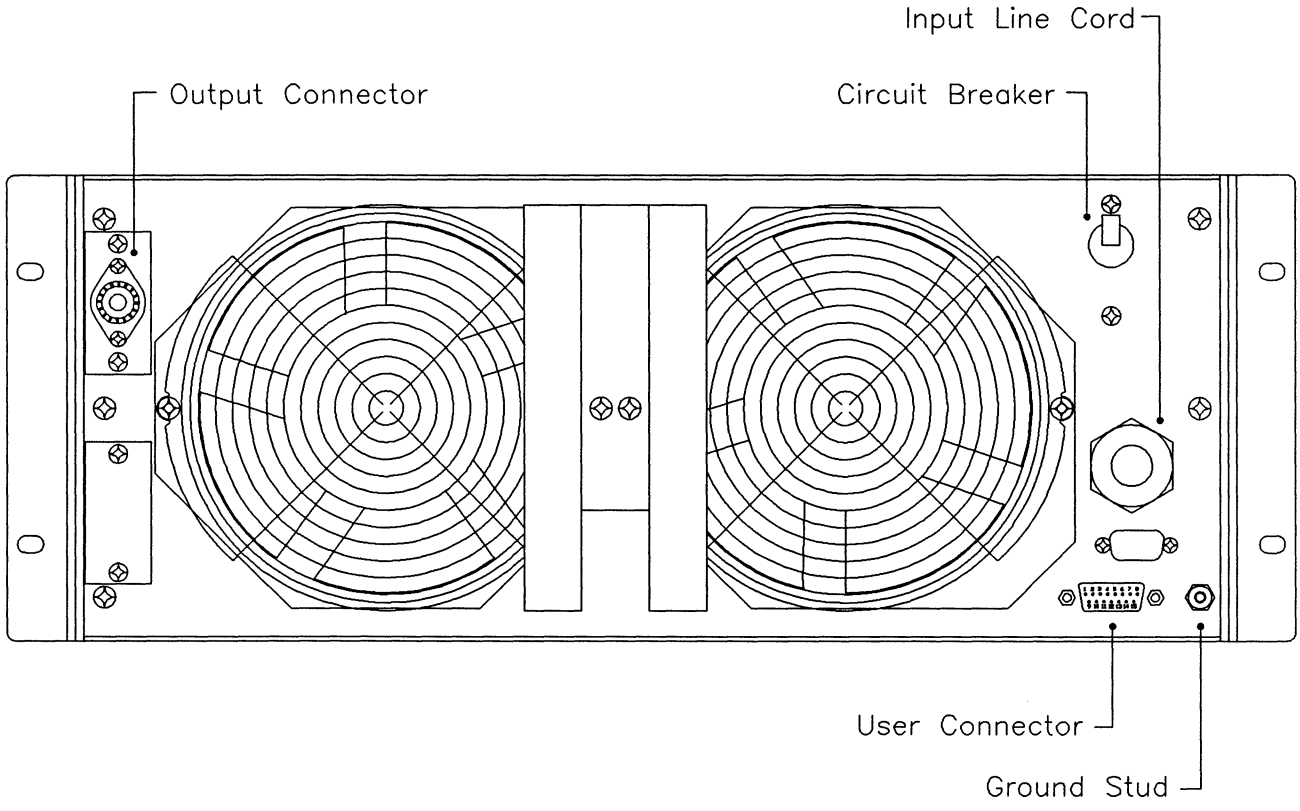

Figure 3-2. Rear panel.

Selecting Two-wire or Three-wire Control

You can select either a two-wire or a three-wire configuration for controlling the **output on/off** in remote mode. In the two-wire configuration, *XOFF.D* (pin 14) and $\overline{\text{XSON.D}}$ (pin 15) function as one input; in the three-wire configuration they function independently. For information on selecting remote mode, see the Choosing Modes section on page 4-3.

Both $\overline{XSON.D}$ and *XOFF.D* are pulled up through a 10 kΩ resistor, so an open circuit is a sufficient high-logic level. A contact closure to POWCOM is a sufficient low-logic level.

As a safety feature, the **OUTPUT ON/OFF** switch on the front panel will turn the output off while the unit is operating in remote mode. If you use three-wire control, the output remains off until you turn it on again. However, if you use two-wire control, the front panel **OUTPUT ON/OFF** switch keeps the output off only as long as you hold the switch in the **OFF** position.

Two-wire control

In a two-wire configuration, a closed contact switch pulls both $\overline{XSON.D}$ and *XOFF.D* low and turns the output on. An open switch pulls both $\overline{XSON.D}$ and *XOFF.D* high and turns the output off. Figure 3-3 shows the wiring diragram for two-wire control.

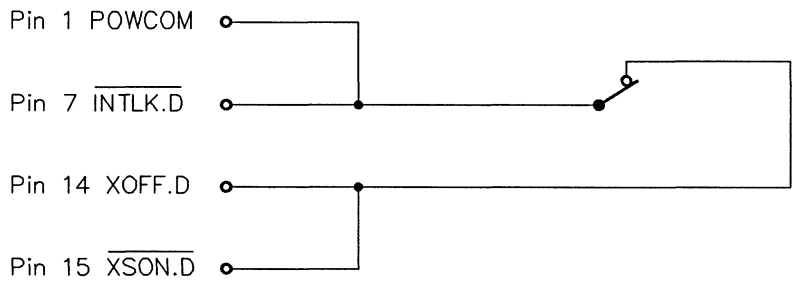

Figure 3-3. Wiring diagram for two-wire control.

Three-wire control

In a three-wire configuration, the momentary contact switch between *XOFF.D* and *POWCOM* is normally closed and the momentary contact switch between $\overline{XSON.D}$ and *POWCOM* is normally open. Fig. 3-4 shows the wiring diragram for three-wire control.

When you first turn the **POWER** switch to **ON**, the output is off; a momentary contact closure between $\overline{XSON.D}$ and *POWCOM* turns the output on. When the output is on, a momentary open contact between *XOFF.D* and *POWCOM* turns the output off.

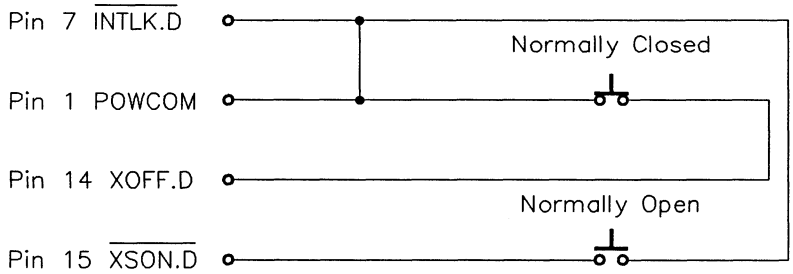

Figure 3-4. Wiring diagram for three-wire control.

Switch Options for Three-Wire Control

To control **output on/off** in remote control, you can use either one 3-position, double-pole switch, or two 2-position, single-pole switches.

Fig. 3-5 shows the wiring diagram for the three-position switch. Table 3-1 shows the output states that result from the three possible switch positions. As shown in Table 3-1, you turn the output on by making momentary contact at switch B, thus closing the circuit between $\overline{XSON.D}$ and *POWCOM*. You turn the output off by making momentary contact at switch A, thus opening the circuit between *XOFF.D* and *POWCOM*. The stable (middle) position maintains the normal contact positions and the unit remains on or off depending on what you most recently selected.

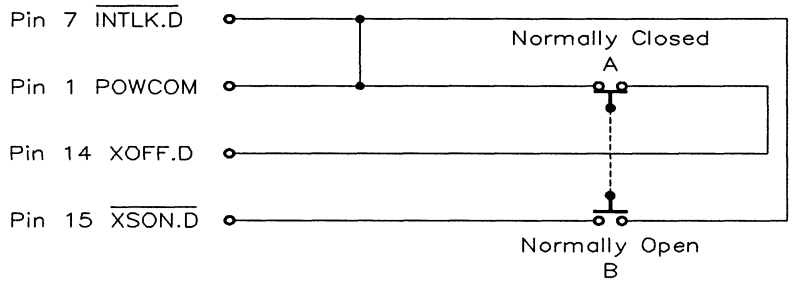

Figure 3-5. Wiring diagram for three-position, double-pole switch.

Table 3-1. Truth table for one 3-position switch showing switch contact states and resulting power output state.

Switch Position	Switch Position State	Switch A Contact State	Switch B Contact State	Power Output State
1	momentary contact	closed	closed	on
2	stable	closed	open	last state selected
3	momentary contact	open	open	off

Fig. 3-6 shows the wiring diagram for the two 2-position switches. Table 3-2 shows the output states resulting from the four possible combinations of the switch position states. As with the three-position switch, momentary contact at switch B closes the circuit between $\overline{XSON.D}$ and *POWCOM* and turns the output on. Momentary contact at switch A opens the circuit between *XOFF.D* and *POWCOM* and turns the output off.

However, pulling $\overline{XSON.D}$ low turns the output on only if the momentary contact switch between *XOFF.D* and *POWCOM* is in its normal position (closed). Therefore, if both switches are held in their momentary positions, the off switch overrides the on switch.

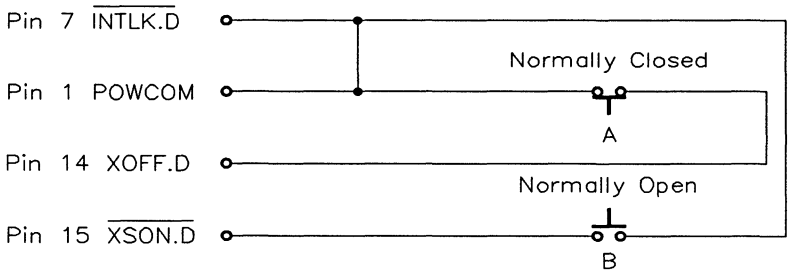

Figure 3-6. Wiring diagram for two 2-position, single-pole switches.

Table 3-2. Truth table for two 2-position switches showing the power output states that result from the four possible combinations of the switch contact states.

Possible Switch Combination	Switch A Position State (Contact State)	Switch B Position State (Contact State)	Power Output State
1	momentary (open)	stable (open)	off
2	stable (closed)	momentary (closed)	on
3	momentary (open)	momentary (closed)	off
4	stable (closed)	stable (open)	last state selected

Establishing Setpoint

After all connections are made and the discharge chamber is prepared, follow these steps for turning on the unit and establishing the setpoint:

1. Turn the **LEVEL** knob and the locking skirt fully counterclockwise.

2. Turn the circuit breaker and the **POWER** switch to **ON**.

   At this time, the display **MONITOR**, and the **LOCAL** and **INTERLOCK** status indicators should light.
   If the **REMOTE** indicator lights instead of the **LOCAL** indicator, see the Troubleshooting section on page 5-7.
   If the **INTERLOCK** status indicator fails to light, check to confirm that the interlock string is satisfied.

3. Move the **OUTPUT ON/OFF** rocker switch momentarily to **ON**. You should hear a contactor close, and the **OUTPUT** status indicator should light.

4. Move the **LEVEL** knob clockwise until the **MONITOR** reads approximately 10% of full output (300 W). The **PLASMA** and **SETPOINT** status indicators should light.

5. To check the output voltage or current, move the **DISPLAY** rocker switch to either the **VOLTAGE** or **CURRENT** setting.

6. Make sure the **SETPOINT** status indicator is lit. Gradually advance the **LEVEL** control knob to the desired power level. If the **SETPOINT** light flashes before the desired power level is reached, check the output voltage on the **MONITOR LED** display. If the voltage is over 600 V, turn off the supply and see the Load Matching section on page 6-5.

   If the ARC indicator light is flashing, turn **POWER OFF**, and go to the see the Troubleshooting section on page 5-7.

7. When you reach the desired power level, lock the **LEVEL** control knob by turning the locking skirt clockwise. The supply can be turned off and on, and the power will return to setpoint automatically.

CHOOSING MODES

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Selecting Remote Control 4-3

Units built prior to 2/6/89 4-3

Units built after 2/6/89 4-3

Selecting Remote Operation

For units built prior to 2/6/89

1. Before removing the plastic safety shield, turn off the supply and let it sit for 5 min. before beginning work.

2. Unscrew the six phillips screws from the top of the power supply and remove the metal cover.

3. Remove the plastic plexiglass safety shield.

4. Three small DIP switches will be visible on the logic board (with the supply facing forward, the logic board faces the front of the supply). The left switch controls the **output on/off**, the middle switch controls the **REMOTE** and **LOCAL** indicators on the **STATUS** display, and the right switch controls the signal source for programming power level. "Up" or C1 is for local operation and "down" or C2 is for remote operation. The DIP switches may be set in any combination. After adjusting the switches, replace the plexiglass cover.

For units built after 2/6/89

1. Turn the **OUTPUT ON/OFF** switch **OFF**.

2. For remote operation of the output power, use a standard screwdriver to rotate the adjustable switch located directly under **OUTPUT ON/OFF** switch on the front panel to **REMOTE**.

3. For remote operation of the signal for programming power level, rotate the switch located directly under the **LEVEL** knob on the front panel to **REMOTE**.

If either of the **LOCAL/REMOTE** switches are in the **REMOTE** position, the **LOCAL** indicator light in the **STATUS** display turns off and the **REMOTE** indicator lights.

PART III

SERVICING YOUR PE SERIES GENERATOR

CALIBRATION AND TROUBLESHOOTING

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Removing the Top Cover of the Supply

Unscrew the six phillips screws from the top of the power supply and remove the metal cover.

Zeroing the Display Monitor

The screws used to make the zeroing adjustment are accessible through the holes in the plexiglass cover. **P ZERO** = Power Monitor; **V ZERO** = Voltage Monitor; **I ZERO** = Current Monitor

1. Before making any zeroing adjustments, turn the **POWER ON/OFF** switch to **ON**, turn the **OUTPUT ON/OFF** switch to **OFF**, and remove the metal cover. Leave the plexiglass cover in place and let the supply sit for at least 3 min.

2. For each value, turn the appropriate screw adjustment using a small standard screwdriver until the front panel display monitor reads zero.

3. Replace the top cover and the six screws.

Maximum Power

The maximum power adjustment clamps the output power to a predetermined limit, independent of local or remote programming. The **MAX PWR** potentiometer is accessible through the holes on the plexiglass cover.

1. Using the **LEVEL** knob on the front panel or the appropriate user I/O signal to set the power to just above the maximum desired operating level.

2. While operating at this level, turn the control **MAX PWR** potentiometer counterclockwise until the displayed power is at the desired clamp point.

Troubleshooting Guide

All servicing functions involving input and output connections can expose you to lethal voltages. Make sure you take proper safety precautions before you troubleshoot the power supply.

These troubleshooting suggestions are included for your convenience. They are only intended to deal with minor problems. If these troubleshooting tips fail to correct problems with the operation of the power supply, please contact the Advanced Energy Industries, Inc. Customer Service Department at:

(303) 221-4670

or at AE's 24 hour service hotline:

(303) 221-0108

Symptom	Things To Check/Remedy
No front panel lights	Make sure the input power cord is connected to appropriate power source. See the Connecting Input section on page 3-5 for appropriate power source/requirements. Make sure the circuit breaker on the rear of the power supply is ON. Make sure the front panel **POWER** switch is **ON**.
No **STATUS** lights except **REMOTE** or **LOCAL**.	Make sure the I/O connector on the rear panel is connected. Make sure the pin connections for the I/O plug are correct. See page 2-13 for an explanation of *XOFF (pin 14).*

INTERLOCK light is flashing.	Check to see if interlock string is complete. If not, see page 2-12 (*pin 7*) for an explanation of the interlock string requirements.
Output of power supply won't turn on.	Check the first two troubleshooting suggestions (No front panel lights and No **STATUS** lights except **REMOTE** or **LOCAL**). If output still won't come on, make sure the **REMOTE/LOCAL** status indicators on front panel are in the desired positions. See the Remote Control section on page 4-3.
No **PLASMA** indication on **STATUS** display.	Make sure the output cable is attached to the rear of the supply. Make sure the vacuum system is at desired pressure. Make sure the correct power level is programmed into the supply. If not, use the **LEVEL** knob or user I/O interface to set the power level to the desired setpoint. See the First Time Operation section beginning on page 3-9. Verify the voltage output indicated on the **MONITOR** display.
Cannot achieve desired power level, but neither the **ARC** or **SETPOINT** indicators on **STATUS** display are flashing.	Make sure the maximum power adjustment is set correctly. See the Maximum Power section on page 5-5.
Cannot achieve full output power and **ARC** and **SETPOINT** indicators on **STATUS** display are flashing.	Disconnect output cable from power supply and enable the output. If the **ARC** indicator is still flashing, call AE Customer Service. Check the system or chamber for low impedance to ground. If a low impedance to ground is present, the problem must be corrected before the supply will function properly.

TROUBLESHOOTING

	Reconnect the power supply to the system. Turn **OUTPUT** switch **ON**. If the **ARC** indicator is still flashing, lower the power level by 20%. After lowering the power level, if the **ARC** indicator is no longer flashing, see the Load Matching section on page 6-7. If the **ARC** indicator is still flashing, call AE Customer Service.
Cannot achieve full power and **SETPOINT** indicator on **STATUS** display is flashing.	Move the **DISPLAY** switch on the front panel to **VOLTAGE**. If the voltage displayed on the **MONITOR** is above 600 V or below 500 V see the Load Matching section on page 6-7. If the voltage is between 500 V and 600 V, call AE Customer Service.
OVERTEMP indicator on **STATUS** display is flashing.	Make sure fans are operating and not blocked. Turn the supply off and call AE Customer Service.

PART IV

THE AE LOAD-MATCHING MODULE

PART IV

LOAD MATCHING

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Load Matching

The load-matching modules used with PE series power supplies are designed as voltage transformers that correctly match the voltage of the power supply to the voltage requirement of the load.

At a given power level and pressure, plasma operates at a fixed voltage level much like back-to-back zener diodes. Load matching is required when this voltage is not in the operating range of the power supply.

Advanced Energy Industries, Inc., load-matching networks consist of a multi-tap auto transformer in a separate load-matching module.

The load-matching module can handle the full rated power output of the associated power supply. It is possible to set up the load-matching module in a voltage step-up or voltage step-down configuration. This capability of stepping-up or stepping-down the supply's output voltage provides increased flexibility.

All AE load-matching modules have dc voltage blocking capacitors in series with the input and the output. These capacitors protect the power supply from excessive dc voltages, which are often present in processes due to the gas type and/or the configuration of the electrodes.

Connecting the Load-matching Module

There is a high voltage potential at both the load-matching and the power supply connection points. Exercise extreme caution when working with this equipment.

Do not make tap changes to load-matching modules while the unit's output power is on. Applying output power while changing tap settings will damage the load-matching module.

Proper load matching can be accomplished by completing the following procedures:

1. Connect the power supply directly to the load without the load-matching module.

2. Turn the **POWER ON/OFF** and **OUTPUT ON/OFF** switches both **ON**. Slowly turn the **LEVEL** knob clockwise until **MONITOR** display shows the desired operating power level. Then increase the power an additional 10%.

3. If the **SETPOINT** indicator light is not flashing at this power level a load-matching module is not required.

4. If the **SETPOINT** indicator light is flashing, a load-matching module is required.

   If you have a LM-5K or LM-10K A:
   Attach the power supply to the terminal on the load-matching module labled **SUPPLY** and the load to the terminal labeled **LOAD**.

   If you have a LM-1.5K, LM-2.5K, or LM-5KA:
   Read the voltage level on the **MONITOR** display by moving the **DISPLAY** switch to **VOLTAGE**.

If the voltage is above 600 V, connect the load-matching module in the step-up mode by attaching the power supply to the **SUPPLY/STEP UP** terminal and the load to the **LOAD/STEP UP** terminal.

If the voltage is below 500 V, then connect the load matching module in the step-down mode by attaching the power supply to the **SUPPLY/STEP DOWN** terminal and the load to the **LOAD/STEP DOWN** terminal.

> Note: It is important to remember that the load matching module is designed to match the voltage of the supply to the voltage of the load. Therefore, the operating range of the power supply at full power is 520 V to 580 V.

5. Select tap 1 on the load match module.

6. Check the voltage on the **MONITOR** display. If the voltage is between 520 V and 580 V, then tap 1 is the appropriate tap. If the voltage is not in this range, turn the power supply **OFF**, change to tap 2 on the load match module, and repeat this process (up to tap 7, if necessary) until the voltage displayed in the **MONITOR** display is between 520 V and 580 V. Once the appropriate tap has been selected for delivering full power into a given process, that tap can be used from zero to full power.

Warranty Claims

Advanced Energy® products are warranted to be free from failures due to defects in material and workmanship for 12 months after they are shipped from the factory (please see warranty statement, below, for details).

In order to claim shipping or handling damage, you must inspect the delivered goods and report such damage to AE within 30 days of your receipt of the goods. Please note that failing to report any damage within this period is the same as acknowledging that the goods were received undamaged.

For a warranty claim to be valid, it must:

- be made within the applicable warranty period
- include the product serial number and a full description of the circumstances giving rise to the claim
- have been assigned a return authorization number (see below) by AE Customer Service

All warranty work will be performed at an authorized AE service center (see list of contacts at the front of the manual). You are responsible for obtaining authorization (see details below) to return any defective units, prepaying the freight costs, and ensuring that the units are returned to an authorized AE service center. AE will return the repaired unit (freight prepaid) to you by second-day air shipment (or ground carrier for local returns); repair parts and labor will be provided free of charge. Whoever ships the unit (either you or AE) is responsible for properly packaging and adequately insuring the unit.

Authorized Returns

Before returning any product for repair and/or adjustment, call AE Customer Service and discuss the problem with them. Be prepared to give them the serial number of the unit and the reason for the proposed return. This consultation call will allow Customer Service to determine if the unit must actually be returned for the problem to be corrected. Such technical consultation is always available at no charge.

Units that are returned without authorization from AE Customer Service and that are found to be functional will not be covered under the warranty (see warranty statement, below). That is, you will have to pay a retest and calibration fee, and all shipping charges.

Upgrading Units

AE's products are continually changing as ways to improve them are discovered. AE is happy to upgrade older units so that they reflect recent improvements. The fee for upgrading a unit will be a percentage of the current list price, based on the age of the unit. Such an upgraded unit will carry a 6-month warranty (which will be added to any time remaining on the original warranty). Contact Customer Service for specifics on getting an older unit upgraded to the current revision level.

Warranty

The seller makes no express or implied warranty that the goods are merchantable or fit for any particular purpose except as specifically stated in printed AE specifications. The sole responsibility of the Seller shall be that it will manufacture the goods in accordance with its published specifications and that the goods will be free from defects in material and workmanship. The seller's liability for breach of an expressed warranty shall exist only if the goods are installed, started in operation, and tested in conformity with the seller's published instructions. The seller expressly excludes any warranty whatsoever concerning goods that have been subject to misuse, negligence, or accident, or that have been altered or repaired by anyone other than the seller or the seller's duly authorized agent. This warranty is expressly made in lieu of any and all other warranties, express or implied, unless otherwise agreed to in writing. The warranty period is 12 months after the date the goods are shipped from AE. In all cases, the seller has sole responsibility for determining the cause and nature of the failure, and the seller's determination with regard thereto shall be final.

AE, World Headquarters
1625 Sharp Point Drive
Fort Collins, CO 80525 USA
Phone: 970.221.0108 or 970.221.0156
Fax: 970.221.5583
Email: technical.support@aei.com

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